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L. M. LEEDS

2,396,708

IMPEDANCE TRANSFORMER

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Fig. 1.

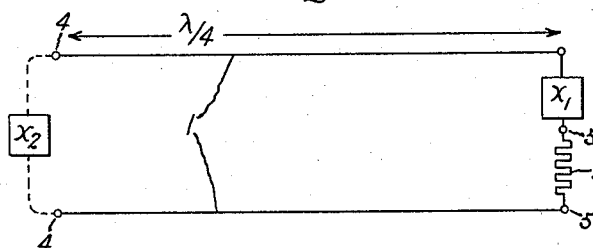
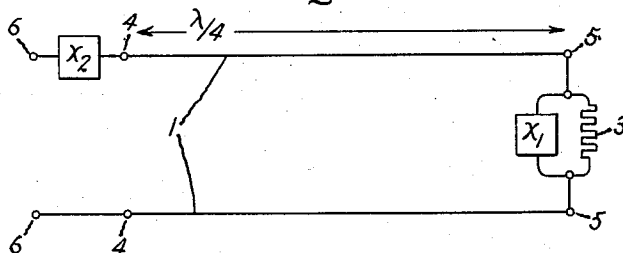


Fig. 2.



Inventor:
Laurance M. Leeds,
by *Harry C. Dunkley*
His Attorney.

UNITED STATES PATENT OFFICE

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IMPEDANCE TRANSFORMER

Laurance M. Leeds, Rotterdam Junction, N. Y.,
assignor to General Electric Company, a corpo-
ration of New York

Application September 14, 1942, Serial No. 458,306

2 Claims. (Cl. 178-44)

The present invention relates to an arrange-
ment for improving the operation of a quarter
wavelength transmission line used as an im-
pedance matching transformer under conditions
where there is unavoidable series or shunt react-
ance. The unavoidable reactance has the effect
of introducing an apparent reactance which has
heretofore been compensated by changing the
length of the transmission line with a resultant
reduction in the transformer ratio.

The object of my invention is to provide an
arrangement in which the effect of unavoidable
reactance is eliminated without changing the
length of the transmission line.

I have found that this object can be accom-
plished by a series (or shunt) reactance at one
end of the transmission line having a value deter-
mined by the unavoidable shunt (or series) re-
actance at the other end of the line.

In the accompanying drawing, Figs. 1 and 2
illustrate applications of the impedance trans-
former embodying my invention.

Referring to Fig. 1 there is shown a quarter
wave-length transmission line having a shunt
reactance X_2 at the input, and a reactance X_1
in series with a resistance 3 at the output. If the
reactances X_2 and X_1 are related by the equation

$$Z_0^2 = X_2 X_1 \quad (1)$$

where Z_0 is the characteristic impedance of the
transmission line, the transformer ratio between
the input terminals 4 and the terminals 5 of the
resistance 3 is given by the equation

$$Z_s = \frac{Z_0^2}{Z_r} \quad (2)$$

where Z_r is the terminating resistance 3 and Z_s
is the apparent value of this resistance measured
at the input terminals 4 . This equation is iden-
tical with that which would be obtained if the
reactances X_2 and X_1 were eliminated. The re-
actances X_1 , X_2 accordingly provide perfect com-
pensation without changing the impedance trans-
former ratio.

The relations set forth above can be proved by
considering the impedance at the input terminals
 4 as equal to the reactance X_2 in parallel with
the rest of the circuit. The input impedance Z_s
will be given by the equation

$$Z_s = \frac{\left(\frac{Z_0^2}{Z_r + jX_1} \right) (jX_2)}{\left(\frac{Z_0^2}{Z_r + jX_1} \right) + (jX_2)} \quad (3)$$

where X_2 and X_1 are either positive (inductance)
or negative (capacity).

The equation reduces to the form

$$Z_s = \frac{(jX_2)Z_0^2}{(jX_2)Z_r - (X_2 X_1) + Z_0^2} \quad (4)$$

from which it is apparent that the impedance
ratio will be given by the equation

$$Z_s = \frac{Z_0^2}{Z_r} \quad (5)$$

if

$$Z_0^2 = X_2 X_1 \quad (6)$$

It will be noted that the reactances X_1 and X_2
may be either inductances or capacitors and that
either may be the unavoidable reactance. In the
most common case, the reactance X_2 will be dis-
tributed capacity which will be compensated by
a capacity X_1 in series with the terminating re-
sistance.

In Fig. 2 the reactance X_1 is in parallel with
the terminating resistance 3 and the reactance
 X_2 is in series with the terminals 4 of the quar-
ter wavelength transmission line 1 .

The impedance connected across the terminals
 5 consists of the terminating resistance Z_r in par-
allel with the reactance X_1 and is equal to

$$\frac{Z_r jX_1}{Z_r + jX_1}$$

where X_1 may be either positive (inductance) or
negative (capacity).

The apparent value at the terminals 4 of the
impedance across the terminals 5 is given by the
equation

$$Z_s = \frac{Z_0^2}{\frac{Z_r jX_1}{Z_r + jX_1}} = \frac{Z_0^2(Z_r + jX_1)}{jX_1 Z_r} \quad (7)$$

The impedance Z_s at the terminals 6 , the input
impedance of the transformer, is equal to the
sum of the reactance X_2 and the impedance at
the terminals 4 is given by the equations

$$Z_s = jX_2 + \frac{Z_0^2(Z_r + jX_1)}{jX_1 Z_r} \quad (8)$$

$$= \frac{Z_0^2 jX_1 + Z_r(Z_0^2 - X_1 X_2)}{Z_r jX_1} \quad (9)$$

If

$$Z_0^2 = X_1 X_2 \quad (10)$$

Equation 9 reduces to

$$Z_s = \frac{Z_0^2}{Z_r} \quad (11)$$

As in Fig. 1, either of the reactances X_1 , X_2
may be inductances or capacities and the effect
of one is compensated by the other.

What I claim as new and desire to secure by
Letters Patent of the United States is:

1. An impedance matching transformer comprising a quarter wavelength transmission line having unavoidable shunt capacity at one end and having a series capacity at the other end having a reactance equal to

$$\frac{Z_0^2}{X}$$

where Z_0 is the characteristic impedance of the transmission line and X is the reactance of the 10 unavoidable shunt capacity.

2. An impedance matching transformer comprising a quarter wavelength transmission line having a series reactance at one end and a shunt reactance at the other end, the reactances having values determined by the equation $Z_0^2 = X_1 X_2$ where Z_0 is the characteristic impedance of the transmission line and X_1 and X_2 are the respective reactances.

LAURANCE M. LEEDS.